

Survey of the reptiles and amphibians of Merriwindi State Conservation Area in the Pilliga forest of northern inland New South Wales

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ABSTRACT

A survey of the herpetofauna of Merriwindi State Conservation Area, a small conservation reserve in the western Pilliga forest in northern inland New South Wales, was done over the period 2009 to 2011. In total, 14 frog species (three families) and 25 reptile species (eight families) were recorded by a combination of diurnal active searches, nocturnal road transects and nocturnal searches of water bodies. The herpetofauna community includes a mix of western (Eyrean), northern (Torresian) and eastern (Bassian) species and demonstrates the significant species diversity and conservation value of the Pilliga forest's herpetofauna. Noteworthy findings from this study included the threatened Pale-headed Snake *Hoplocephalus bitorquatus*, a number of declining woodland reptile species such as the Nobbi *Diporiphora nobbi*, Brown-blazed Ctenotus *Ctenotus allotropis* and Australian Coral Snake *Brachyurophis australis*, and the first documented record of the Striped Burrowing Frog *Cyclorana alboguttata* from the western Pilliga forest. This study provides a useful benchmark of the composition and status of the herpetofauna community of Merriwindi SCA in the early years following a land management shift from timber production to conservation.

Key words: Herpetofauna community, temperate woodland, Pilliga forest, Brigalow Belt South bioregion, field survey methods

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Introduction

The Pilliga forest (30°25'–31°15'S, 148°40'–149°50'E) is a 450 000 ha area of woodland and open forest in Gamilaraay Aboriginal Country in the Brigalow Belt South bioregion in northern inland New South Wales (NSW), and is between 290 and 420 km inland from the Australian east coast. The majority of native vegetation on more productive soils in the surrounding area has been cleared for agriculture, with the Pilliga forest left as a large dry woodland remnant on the poorest sandy soils. The landform of the Pilliga forest ranges from low sandstone hills and broad sandy valleys in the south-east to a flat outwash sand plain in the west and north, and aquatic habitats are ephemeral and of limited extent and variety (Murphy 2011; Murphy and Shea 2013).

The Pilliga forest is the largest surviving area of native forest west of the Great Dividing Range in NSW and is a key area for biodiversity conservation in the NSW sheep-wheat belt (Date *et al.* 2002; Turbill and Ellis 2006; Murphy 2011; Murphy and Shea 2013). Merriwindi State Conservation Area (SCA) (formerly part of Merriwindi State Forest) was dedicated in December 2005 under the NSW *Brigalow and Nandewar Community Conservation Area Act 2005* as 1 of 10 new conservation reserves in the Pilliga forest, and is located in the western outwash part of the Pilliga forest. The primary aim of the present study was to identify the extant herpetofauna of Merriwindi SCA and provide information to assist in the management of this new conservation reserve. A secondary aim was to

examine the effectiveness of various herpetofauna survey methods in the Pilliga forest.

A description of the reptile community of Merriwindi State Forest in the mid 1960s (at that time including Merriwindi SCA) by Bustard (1968a), from data collated during a series of ecological field studies (Bustard 1968b, 1968c, 1970, 1971), was one of the first published accounts of the reptile community associated with a particular habitat type in Australia. The present study also provided an opportunity to examine whether this community had changed after the passage of over 40 years.

Study area and methods

Merriwindi SCA (Figure 1) is a relatively small reserve at 1730 ha. It is located 17 km NNW of the town of Baradine on the flat outwash plain of the western Pilliga forest and adjoins Merriwindi State Forest to the south and east, farmland to the west and north and Pilliga West State Forest to the north-west. The reserve has an elevation ranging from 246–261 m (Australian Height Datum). Outcrops of rock are entirely absent and the soil is a Quaternary sandy alluvium. The vegetation is dry open forest dominated by Narrow-leafed Ironbark *Eucalyptus crebra*, White Cypress Pine *Callitris glaucophylla* and Bullocke *Allocasuarina luehmannii* with some Pilliga Box *E. pilligaensis*, Baradine Red Gum *E. chloroclada* and Rough-barked Apple *Angophora floribunda*. Aquatic habitat is very limited but includes a small ephemeral gilgai wetland as well as two small anthropogenic ground tanks (Trap Yard dam and Log

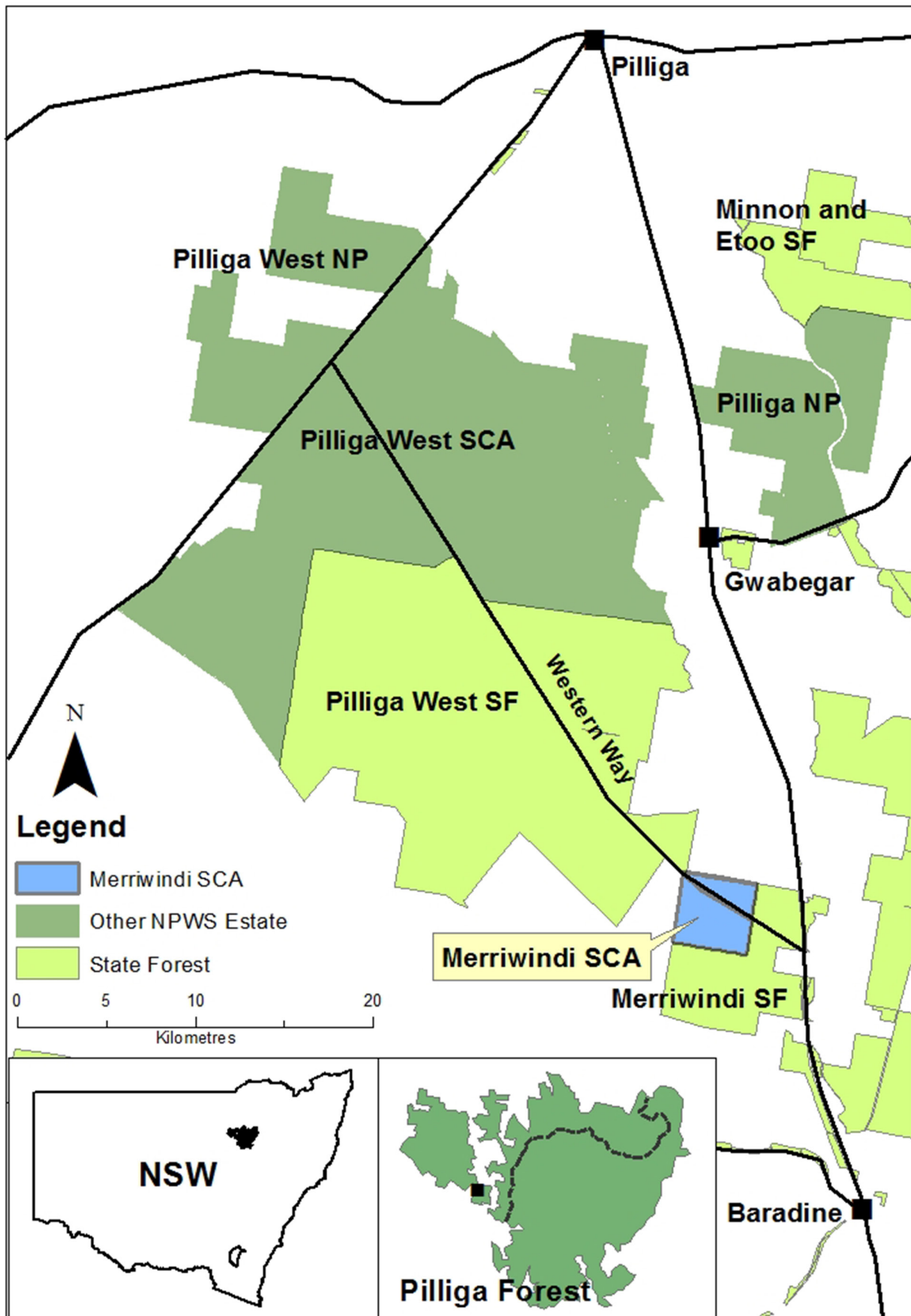


Figure 1. Location of Merriwindi SCA. The first inset map shows the location of the Pilliga forest in northern inland NSW. The second inset map shows the context of Merriwindi SCA (black square) in the Pilliga forest (green area). The dotted line marks the boundary between the south-eastern sandstone country and the outwash plain in the west and north. The main map shows current land tenure in the western Pilliga forest. NP = national park, SCA = state conservation area, SF = state forest.

dam). Surviving evidence of past forestry activities includes piles of railway sleeper offcuts, standing dead ring-barked trees, logging debris and cut tree stumps. The reserve is now managed for conservation by the NSW National Parks and Wildlife Service (NPWS).

A field survey using a range of systematic and opportunistic methods (Table 1) was done in Merriwindi SCA over the period October 2009 to June 2011. Trapping such as dry pitfall trapping or funnel-trapping was not employed in this study because the fieldwork was done episodically (a reflection of the volunteer basis of the work) rather than in longer block periods, so that traps could not be regularly checked. Voucher specimens of several species recorded were lodged in the collection of the Australian Museum (Sydney). A review of available local records and assessment of habitat suitability was also done in order to identify additional species which may potentially occur in Merriwindi SCA. Local records were obtained from published papers, unpublished reports, the Office of Environment and Heritage Atlas of NSW Wildlife, records of the senior author and discussion with other local NPWS staff. Nomenclature in this paper follows Cogger (2014).

Results

In total, 39 species were recorded during the field survey: 14 frogs representing eight genera in three families and 25 reptiles representing 21 genera in eight families. Voucher specimens collected as part of the survey are listed in Appendix 1 and photographs of a selection of the species recorded are shown in Appendix 2. A complete list of the species recorded is provided in Table 2, together with information on the number of records by each survey method and microhabitats utilised by each species. The

most frequently recorded frogs were *Litoria latopalmata* and *Litoria rubella*. The most frequently recorded reptile was *Heteronotia binoei* (representing 30% of all reptile records documented) followed by *Gehyra variegata* and *Egernia striolata*. Rarely recorded species included *Notaden bennetti*, *Chelodina longicollis*, *Hoplocephalus bitorquatus* and *Vermicella annulata*. Most frogs were commonly associated with water bodies although one species, *Platyplectrum omatum*, was more frequently found away from water. Large woody debris and loose bark on trees, stumps and logs were important shelter microhabitats for almost half of the reptile species recorded.

The number of species recorded by each survey method and the number of species recorded by only one method is summarised in Table 3. Overall there were 20 species (over half the total) that were detected by single survey methods, rising to 24 species if systematic and opportunistic diurnal search results are pooled. Diurnal active searching, nocturnal searching around water bodies and nocturnal road transects all contributed substantially to the overall species total. Placement of corrugated iron as artificial shelter and checking roads for vehicle-killed animals identified relatively few species and were redundant in this study with respect to contributing additional species. The shape of cumulative species curves from the timed diurnal searches, timed nocturnal water body searches and nocturnal road searches (Figure 2) give an indication of the likelihood of adding species with continued effort. Information concerning an additional one frog and eight reptile species which have been recorded in the western Pilliga forest (Figure 1), and which may occur in Merriwindi SCA on the basis of available habitats, is summarised in Table 4.

Table 1. Herpetofauna field survey methods employed in Merriwindi SCA.

Survey method	Description	Survey effort	Timing
a. Timed active diurnal search for reptiles	Search of 2 ha area for minimum of 30 minutes looking for active animals and investigating potential shelter sites.	45 sites	Sept to May
b. Timed nocturnal search of water bodies for frogs	Search around margin of ground tank or ephemeral water body for minimum of 30 minutes looking for active animals and listening for calls.	20 searches	Sept to Jan
c. Nocturnal road searches for reptiles and frogs	Walking or driving along roads and fire trails for minimum of 60 minutes looking for active animals.	14 nights	Oct to Apr
d. Placement of artificial shelter	Sheets of corrugated roofing iron placed on the ground and checked at intervals for any animals sheltering beneath.	3 sites (4-5 sheets per site). Total of 176 sheet-inspections	Throughout year
e. Opportunistic active diurnal search for reptiles and frogs.	Non-constrained searching for active animals and investigation of potential shelter sites. Included incidental observations of active animals while travelling between survey sites as well as opportunistic active searching.	-	Throughout year
f. Opportunistic search for animals dead on roads.	Main road through reserve (Western Way) regularly checked for animals killed by traffic.	-	Throughout year

Table 2. Frogs and reptiles recorded in Merriwindi SCA 2009-2011.

Survey method: A = timed diurnal active search, B = timed nocturnal search of water bodies, C = nocturnal road search, D = artificial shelter, E = opportunistic diurnal active search, F = dead on road. Note numbers given are not number of individual animals. For systematic methods (A – D) = number of surveys when species recorded and for opportunistic methods (E and F) = number of records. **Microhabitat:** B = under loose bark on tree trunks, stumps and large logs, D = under large woody debris on ground, F = fossorial, G = active on ground surface, T = active on surface of tree trunks, major branches and large woody debris, U = under corrugated iron on ground, W = in or on margins of water bodies.

Scientific name	Common name	Survey method						Sum	Microhabitat
		A	B	C	D	E	F		
Limnodynastidae									
Limnodynastes fletcheri	Barking Marsh Frog	-	3	-	-	-	-	3	W
Limnodynastes tasmaniensis	Spotted Marsh Frog	-	9	-	-	2	-	11	GW
Limnodynastes terraereginae	Northern Banjo Frog	-	5	3	-	1	-	9	GW
Neobatrachus sudelli	Common Spadefoot Toad	-	3	-	-	-	-	3	W
Notaden bennetti	Holy Cross Toad	-	1	-	-	-	-	1	W
Platyplectrum ornatum	Ornate Burrowing Frog	-	3	6	-	-	-	9	GW
Myobatrachidae									
Crinia parinsignifera	Plains Froglet	-	2	-	-	-	-	2	W
Uperoleia rugosa	Wrinkled Toadlet	-	10	-	-	2	-	12	DW
Hylidae									
Cyclorana alboguttata	Striped Burrowing Frog	-	3	1	-	-	-	4	GW
Cyclorana platycephala	Water-holding Frog	-	6	-	-	-	-	6	GW
Litoria caerulea	Green Tree Frog	-	8	4	-	-	-	12	GW
Litoria latopalmata	Broad-palmed Frog	1	18	1	-	1	-	21	DGW
Litoria peronii	Peron's Tree Frog	-	12	-	-	1	-	13	DW
Litoria rubella	Desert Tree Frog	-	10	4	1	1	-	16	DGWU
Chelidae									
Chelodina longicollis	Eastern Snake-necked Turtle	-	1	-	-	-	-	1	W
Diplodactylidae									
Diplodactylus vittatus	Eastern Stone Gecko	-	-	10	-	-	-	10	G
Oedura monilis	Ocellated Velvet Gecko	10	-	4	-	4	-	18	BG
Strophurus williamsi	Eastern Spiny-tailed Gecko	-	-	1	-	1	-	2	BG
Geckonidae									
Gehyra dubia	Dubious Dtella	2	-	-	-	-	-	2	B
Gehyra variegata	Common Dtella	23	-	5	-	2	-	30	BDG
Heteronotia binoei	Prickly Gecko	39	-	6	21	13	-	79	BDGU
Scincidae									
Cryptoblepharus pannosus	Ragged Snake-eyed Skink	7	-	-	-	-	-	7	T
Ctenotus allotropis	Brown-blazed Ctenotus	2	-	-	-	-	-	2	G
Egernia striolata	Tree Skink	24	-	-	-	3	-	27	BDT
Lerista punctatovittata	Eastern Robust Slider	6	-	-	-	-	-	6	DF
Lerista timida	Timid Slider	16	-	-	-	1	-	17	DF
Morethia boulengeri	South-Eastern Morethia Skink	15	-	-	3	1	-	19	DGU
Agamidae									
Amphibolurus burnsi	Burn's Dragon	3	-	-	-	-	-	3	D
Diporiphora nobbi	Nobbi	3	-	-	-	-	-	3	G
Pogona barbata	Eastern Bearded Dragon	5	-	-	-	2	-	7	GT
Varanidae									
Varanus gouldii	Sand Goanna	1	-	-	-	3	-	4	G
Varanus varius	Lace Monitor	3	-	-	-	4	1	8	GT
Typhlopidae									
Ramphotyphlops ligatus	Blind Snake	-	-	2	-	-	-	2	G
Elapidae									
Brachyurophis australis	Australian Coral Snake	-	-	2	-	-	-	2	G
Furina diadema	Red-naped Snake	2	-	-	-	-	-	2	D
Hoplocephalus bitorquatus	Pale-headed Snake	-	-	1	-	-	-	1	T
Parasuta spectabilis dwyeri	Spectacled Hooded Snake	-	-	1	-	-	-	1	G
Pseudechis guttatus	Blue-bellied Black Snake	-	-	1	-	-	-	1	G
Vermicella annulata	Eastern Bandy-Bandy	1	-	-	-	-	-	1	DF

Table 3. Summary of survey results: number of species recorded by each method and number of species unique to that method.

Survey method & target group	No. species recorded	No. species recorded only by this method
Active diurnal search (systematic & opportunistic surveys combined) (reptiles)	6 frogs & 18 reptiles	12 reptiles
Timed nocturnal search of ground tanks and ephemeral water bodies (frogs)	14 frogs & 1 reptile	5 frogs & 1 reptile
Nocturnal road searches (frogs & reptiles)	6 frogs & 10 reptiles	6 reptiles
Placement of artificial shelter (reptiles)	1 frog & 2 reptiles	nil
Opportunistic search for animals dead on roads (frogs & reptiles)	1 reptile	nil

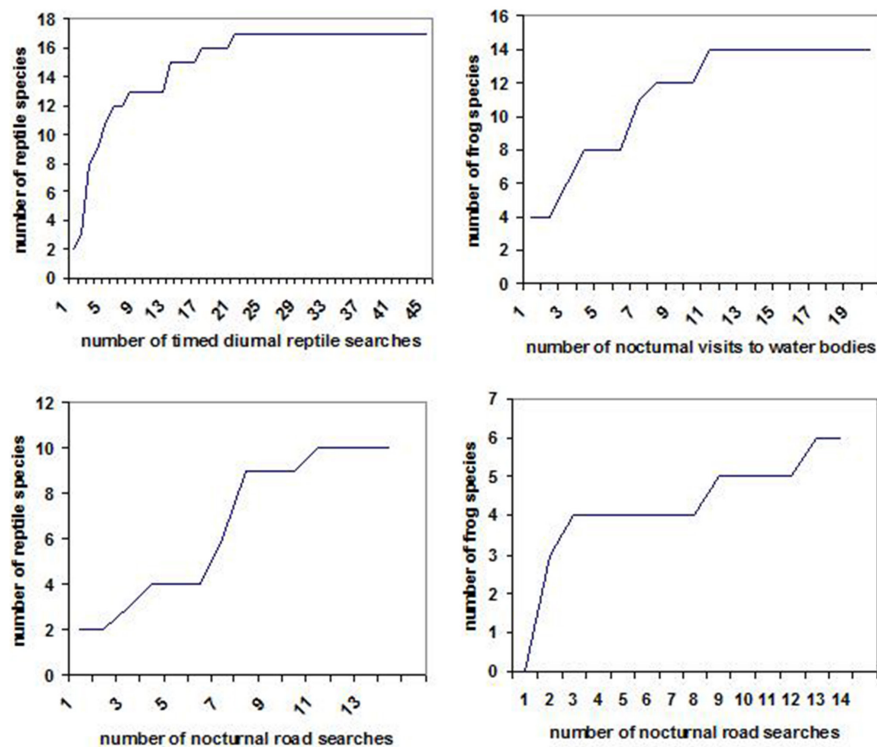


Figure 2. Cumulative species curves showing return for effort for three systematic survey methods.

Table 4. Additional species known from western Pilliga forest and potentially occurring in Merriwindi SCA.

Scientific name	Common name	Local records
Limnodynastidae		
<i>Limnodynastes salmini</i>	Salmon-striped Frog	Pilliga West SCA May 2007 (Murphy record) Pilliga West SCA Jan 2010 (Murphy record)
Pygopodidae		
<i>Lialis burtonis</i>	Burton's Legless Lizard	Merriwindi SF (Bustard 1968a)
Scincidae		
<i>Ctenotus robustus</i>	Striped Skink	Merriwindi SF (Bustard 1968a) Merriwindi SF (Atlas of NSW Wildlife)
<i>Menetia greyii</i>	Common Dwarf Skink	Merriwindi SF (Atlas of NSW Wildlife)
<i>Tiliqua scincoides</i>	Common Bluetongue	Merriwindi SF (Bustard 1968a)
Agamidae		
<i>Amphibolurus muricatus</i>	Jacky Lizard	Merriwindi SF (Bustard 1968a) Merriwindi SCA Oct 2009 (NPWS 2010)
Boidae		
<i>Morelia spilota metcalfei</i>	Inland Carpet Python	Pilliga West SF Mar 2011 (D.Wurst NPWS pers. comm.)
Elapidae		
<i>Demansia psammophis</i>	Yellow-faced Whipsnake	Merriwindi SF (Bustard 1968a) Pilliga West SF (Atlas of NSW Wildlife) Pilliga West NP Jan 2010 (Murphy record)
<i>Pseudonaja textilis</i>	Eastern Brown Snake	Merriwindi SF Apr 2008 (Murphy record)

Discussion

Species diversity and significant species

Merriwindi SCA was found to support a very diverse frog and reptile fauna given its small size and relatively limited variety of habitats. The diversity of species is in part due to the location of the study area in a transitional zone between western (Eyrean), northern (Torresian) and eastern (Bassian) faunal assemblages. The western

influence on the herpetofauna predominates and includes species such as *Cyclorana platycephala*, *Neobatrachus sudelli*, *Heteronotia binoei*, *Lerista punctatovittata* and *Ramphotyphlops ligatus*. The northern influence is also significant, with examples including *Cyclorana alboguttata*, *Limnodynastes terraereginae*, *Platyplectron ornatum*, *Oedura monilis* and *Amphibolurus burnsi*. A minor eastern influence on the herpetofauna is limited to the presence of a few widespread Bassian species such as *Varanus varius*, *Pogona barbata* and *Chelodina longicollis*.

The context of the reserve in the surrounding landscape is another factor in the high diversity of species found in Merriwindi SCA. Unlike many similar-sized small reserves on the NSW western slopes, which are isolated remnants in an agricultural matrix, Merriwindi SCA is part of a much larger area of continuous native forest (Figure 1). Habitat loss and fragmentation can result in changes to herpetofauna communities through the disappearance of disturbance-sensitive species (Sarre *et al.* 1995; Sumner *et al.* 1999; Diaz *et al.* 2000; Driscoll 2004; Brown *et al.* 2008). The decline of Australia's woodland herpetofauna in agriculture-dominated bioregions is comparable to the plight of woodland birds (Barrett *et al.* 1994; Recher 1999; Watson *et al.* 2002; Ford *et al.* 2009; Ford 2011; Watson 2011) but has received substantially less attention. Species from the present study which have been identified as declining in agricultural landscapes include *Ctenotus allotropis*, *Diporiphora nobbi* and *Brachyurophis australis* (Driscoll 2004).

Merriwindi State Forest was (and remains) larger than Merriwindi SCA (Figure 1) and includes riparian habitat on the eastern boundary that is not present in the SCA. Nevertheless, it is interesting to compare the Merriwindi area's reptile community as documented by Bustard (1968a) with that over 40 years later in the present study. Bustard (1968a) documented 26 reptile species in Merriwindi State Forest (including Merriwindi SCA), of which 21 species were in common with the present study. *Lialis burtonis*, *Ctenotus robustus*, *Tiliqua scincoides* and *Demansia psammophis* from Bustard (1968a) are additional to the present study. These four species remain extant in the Pilliga forest, with recent (post-2006) records from elsewhere in the area (Murphy unpublished data). *Chelodina longicollis*, *Ramphotyphlops ligatus* and *Vermicella annulata* from the present study are missing from the earlier work. All seven species were recorded as being only rare to uncommon or seldom seen in the Merriwindi area (Bustard 1968a; this study), so false negatives are likely. Bustard (1968a) also reported *Amphibolurus muricatus* as common in Merriwindi State Forest; however, *Diporiphora nobbi* was not described as a separate species until 1972 (Witten 1972). We suggest that the animals seen by Bustard (1968a) probably refer to *D. nobbi*, which is the common small dragon in the Pilliga forest (Murphy pers. obs.). We have not seen *A. muricatus* in the Pilliga forest, although it may occur there in small numbers. The two species can be readily distinguished by mouth colour (Swan *et al.* 2004). There is a single unconfirmed recent report of *A. muricatus* from Merriwindi SCA (NPWS 2010). Other differences between Bustard (1968a) and the present study include the relative abundance of some species. Bustard (1968a), for example, recorded only four individuals of *Lerista timida* (as *Ablepharus timidus*) in five years, while it was common in the present study, being detected in 16 (36%) of the timed diurnal active searches. These and other differences between the two studies may be due to differences in survey methods, habitat changes over the intervening period and/or climate conditions at the time of survey.

Bustard (1968a) described Merriwindi State Forest as being arid habitat unsuitable for frogs. The present authors were fortunate that considerable rainfall during

La Niña conditions over the summer and autumn of 2010 filled ephemeral wetlands in the Pilliga forest and initiated major frog breeding events. Multi-species simultaneous breeding aggregations of up to 10 frog species were recorded in Merriwindi SCA. This included a variety of burrowing species, which can often go undetected if surveys do not coincide with favourable weather conditions (Fletcher 1892; Murphy 1997; Murphy 2012). The present survey included the first documented records of *Cyclorana alboguttata* in the Pilliga Outwash forest (Atlas of NSW Wildlife and Atlas of Living Australia checked 25 April 2015). The remarkable richness of the frog fauna of the 1730 ha Merriwindi SCA can be illustrated by comparing the 14 species recorded in the present survey to the 17 frog species known from the Macquarie Marshes (approximately 110 km west), a wetland system of over 200 000 ha noted as having one of the highest frog diversities of any wetland system in the Murray-Darling Basin (Threatened Species Scientific Committee 2013). The present senior author has recorded 18 frog species in the Pilliga forest (Murphy unpublished data). The high proportion of native woodland cover comprising stream catchments in the Pilliga forest is probably a major factor in the survival there of a surprisingly diverse and relatively intact aquatic fauna including frogs as well as macro-invertebrates such as crustaceans and molluscs (Murphy 2011; Murphy and Shea 2013).

The Pale-headed Snake *Hoplocephalus bitorquatus* was the species of highest conservation concern recorded in this study, currently listed as 'vulnerable' (defined as species facing a high risk of extinction in NSW in the medium term future) under the NSW *Threatened Species Conservation Act 1995*. This medium-sized elapid snake is a nocturnally active obligate tree-hollow dweller feeding primarily on frogs (Shine 1983; Fitzgerald *et al.* 2010). A single adult animal was found at night in January 2010, about 2 m above the ground, climbing up the trunk of a large live Baradine Red Gum with hollows. When released the snake continued climbing the tree trunk, taking advantage of pieces of loose bark for support, and was last seen at a height of about 5 m. *Hoplocephalus bitorquatus* was also recorded in Merriwindi State Forest in April 1964: a single animal sheltering about 1 m above the ground under the loose bark of a tall White Cypress Pine stump (Bustard 1968a).

Survey effectiveness

Various studies have shown that a range of complementary field survey methods are needed in order to detect the greatest proportion of species present in an area (Milton 1980; Parris *et al.* 1999; Garden *et al.* 2007; Murphy and Murphy 2011). In the present study a combination of diurnal active searches, nocturnal road transects and nocturnal searches of water bodies was needed to identify the full range of species. For example, *Diplodactylus vittatus* was not recorded at all during diurnal active searching but was the most commonly recorded gecko at night. Evidently active searches failed to locate any diurnal shelter sites of this species.

The relatively low traffic volume on Western Way (averaging less than 50 vehicles per day from NPWS car counter data) is probably the main reason for the poor result from

checking roads for dead animals. This method can be quite productive, depending on traffic volume and luck (e.g. Armstrong & Reid 1992; Murphy 1994). The record of *Pseudonaja textilis* cited in Table 4 was a roadkill specimen collected on Western Way 2 km south-east of Merriwindi SCA (Murphy record AM specimen R.174277). Similarly, the placement of corrugated iron sheets in this study identified only three common species and did not add to the species tally. This method has proved useful in other studies (e.g. Daly *et al.* 2008; Murphy and Murphy 2011) and the poor result in the present study may be due to the relatively low number of sheet-inspections and, possibly, low population densities of the target species (elapid snakes).

Despite the considerable survey effort expended on systematic timed diurnal searches for reptiles and the flatness of the resulting cumulative species curve (Figure 2), one additional species, *Strophurus williamsi*, was located by opportunistic diurnal searching. This species spends the warmer months high in trees, descending to hibernate near the base of trees and stumps over winter (Bustard 1968a; Swan *et al.* 2004). The systematic diurnal surveys were done between late September and mid May while the opportunistic diurnal record was of two adult animals together under the loose bark of a 2 m high cypress pine stump in August. Bustard (1968a) captured and marked 152 *S. williamsi* individuals in Merriwindi State Forest over three winters.

Some frogs, such as *Litoria caerulea*, *Platyplectrum omatum* and *Limnodynastes terraereginae*, were recorded on nocturnal road transects before they were found at water bodies, while others such as *Cyclorana platycephala*, *Limnodynastes fletcheri* and *Crinia parinsignifera* were only detected at water bodies. The success of nocturnal searches of water bodies depended to a great extent on suitable weather. Only eight species were recorded around water bodies prior to wet weather and the filling of ephemeral wetlands. Eventually all 14 frog species were recorded at water bodies. The unusual shape of the cumulative curve for detection of reptiles by nocturnal road transects (Figure 2) reflects the weather-dependence of this method as well. Warm to hot nights following recent rain were the best conditions for detection of reptiles. Nocturnal road searching has been identified as a good method for detecting snakes (Milton 1980; Murphy and Murphy 2011). In the present study this survey method detected the most snake species (five out of seven), providing the only survey records of these five species and also detected the most gecko species (five out of six).

Six herpetofauna species detected in the present survey (15% of the total) were represented by only single records, suggesting that additional species present may have gone undetected. In addition to *Lialis burtonis*, *Ctenotus robustus*, *Tiliqua scincoides*, *Demansia psammophis* and possibly *Amphibolurus muricatus* as noted above, another four species known from the western Pilliga forest may occur in the study area: *Limnodynastes salmini*, *Menetia greyii*, *Morelia spilota* and *Pseudonaja textilis*. Snakes are over-represented as single-record species and as possible additional species, a reflection that standard fauna survey methods frequently under-sample snakes (Woinarski *et al.* 2000; Murphy and Murphy 2011).

The collection of voucher specimens and subsequent lodging in public museum collections is an important part of fauna surveys (Greer 2006). This is particularly relevant to Australian herpetology, where we still have much to learn. Over 200 new species of Australian herpetofauna have been described in the last 20 years (Cogger 2014). Voucher specimens collected during the present study enabled the identification of problematic species such as blind snakes and recently described species such as *Cryptoblepharus pannosus* (Horner 2007) to be confirmed and will also be available as reference material in the event of future taxonomic revisions. Reference to Bustard (1968a) demonstrates the extent to which even scientific names can change over time and become all but unrecognizable, such as *Ablepharus lineo-ocellatus anomalus* (now *Morethia boulengeri*) and *Sphenomorphus lesueurii lesueurii* (now *Ctenotus robustus*).

Management considerations

This survey identified a large and varied herpetofauna community in Merriwindi SCA. Significant habitat features for herpetofauna included ephemeral wetland areas, large woody debris, hollow-bearing trees and standing dead trees with loose bark. The small gilgai on the western edge of the SCA (Appendix 2) and the low-lying area around Trap Yard dam are important ephemeral wetland areas for breeding frogs and should be protected from any ground disturbance. Large woody debris with habitat value included piles of railway sleeper offcuts from previous forestry activity in addition to natural logs. Hollow-bearing trees are critical to the conservation of the threatened *Hoplocephalus bitorquatus* (Fitzgerald *et al.* 2010), and are probably also important in the survival of tree frogs during wildfires (Murphy 2008). Parnaby *et al.* (2011) noted that the average age for formation of large hollows in eucalypts in the Pilliga forest was likely to exceed 250-400 years, highlighting the importance of protecting existing habitat trees. Standing dead trees in the SCA are predominantly a legacy of the early forest management practice of ring-barking (Bustard 1968a). The present study was done only four to six years following gazettal as a SCA and a management shift from timber production to conservation. Succession from a disturbed regrowth forest to a mature or old-growth forest will take many decades and possibly even centuries. A decrease in population densities (and ease of detection) of some currently common herpetofauna species and an increase in some currently rare species can be anticipated as the reserve slowly returns to a more natural forest structure. Surprisingly, Duckett and Stow (2011) found that significant differences in forest structure and degree of genetic structuring in populations of *Gehyra variegata* were already discernible between state forest sites and conservation reserve sites in the Pilliga outwash forests, only six years or less after the gazettal of these reserves. It is considered likely the sites studied had different forestry management histories prior to reserve gazettal.

A positive perspective on the scarcity of roadkill animals in this study is that vehicular traffic through the reserve at the current level is unlikely to be a threat to the survival of herpetofauna populations. Fire management in the reserve should be aimed at maintaining a natural

fire regime and avoiding a large proportion of the reserve burning in one event. Large old trees with hollows are at significant risk from fire (Parnaby *et al.* 2010; Parnaby *et al.* 2011) and their protection is an objective during both hazard reduction burns and wildfire events. Current weed and feral pest control programs by the NPWS in the western Pilliga forest are likely to benefit the herpetofauna community. The north-west corner of the SCA forms a narrow linkage to Pilliga West State Forest and the rest of the western Pilliga forest (see Figure 1). Habitat connectivity in this area needs to be protected and, if possible, enhanced in cooperation with neighbouring landholders. Narrow linear forest remnants along roadsides and streams that link Merriwindi State Forest to the central Pilliga forest to the east should similarly be protected and enhanced.

Conclusion

As one of the largest surviving woodland remnants on the inland western slopes of south-eastern Australia, the Pilliga forest provides valuable insight into the original herpetofauna of the western slopes prior to landscape-scale agricultural development. The present study illustrates the significant biogeographical interest, species diversity and conservation value of the herpetofauna community of the outwash forests of the western Pilliga. The information documented in this study provides a useful benchmark of the status and composition of the herpetofauna community of Merriwindi SCA in the early years following a management shift from timber production to conservation. This information, together with that provided by Bustard (1968a), will be useful in future assessment of the herpetofauna community of Merriwindi SCA and the broader Pilliga forest.

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APPENDIX I

Voucher specimens collected from Merriwindi SCA during this study and lodged in the Australian Museum, Sydney.

Uperoleia rugosa R174478, R174479, R174480; *Strophurus williamsi* R174485; *Gehyra dubia* R175751; *Cryptoblepharus pannosus* R175752; *Lerista timida* R174481, R174482; *Morethia boulengeri* R174486; *Diporiphora nobbi* R174487; *Ramphotyphlops ligatus* R174477, R174484.

APPENDIX 2



Pilliga Box-White Cypress Pine open forest in Merriwindi SCA with large woody debris from previous railway sleeper cutting. Skilled field herpetologists engaged in active diurnal searches rely on detailed knowledge of shelter site attributes and scanning for active animals at different distances. Photo: S.J. Murphy.



Ephemeral gilgai wetland, Belah Road, Merriwindi SCA, during *La Niña* conditions in 2010. This site had multi-species breeding aggregations of up to nine frog species and also provided the only record of the Eastern Snake-necked Turtle *Chelodina longicollis*. Photo: M.J. Murphy.



The Barking Marsh Frog *Limnodynastes fletcheri* (photographed at Merriwindi) was part of the rich frog fauna in the reserve and was only recorded after substantial rain filled ephemeral wetlands. Photo: M.J. Murphy.



Observations of the Striped Burrowing Frog *Cyclorana alboguttata* (photographed at Merriwindi) in this study were the first documented records of this northern (Torresian) species in the western Pilliga forest. Photo: M.J. Murphy.

APPENDIX 2



The Broad-palmed Frog *Litoria latopalmata* (photographed at Merriwindi) is a ground-dwelling tree frog and is the most commonly encountered frog in the Pilliga forest. It shelters by day under debris and can often be found around the margins of ground tanks and other water bodies at night. Photo: M.J. Murphy.



The Ocellated Velvet Gecko *Oedura monilis* (photographed at Merriwindi), one of six gecko species found in the reserve, favours the narrow spaces under loose bark on standing dead trees and large woody debris for diurnal shelter. Photo: M.J. Murphy.



The Eastern Spiny-tailed Gecko *Strophurus williamsi* (photographed at Merriwindi) spends the summer in the canopy and retreats to stumps and the base of trees during winter. The animal pictured is in a defensive posture, exuding a sticky fluid thought to discourage predators. Photo: M.J. Murphy.



The Tree Skink *Egernia striolata* (photographed at Merriwindi) is a social species often living in small groups in tree hollows, hollow logs, under loose bark and in rock crevices. Group size at Merriwindi was typically only two to three animals. Photo: M.J. Murphy.

APPENDIX 2



The Spotted Lerista *Lerista punctatovittata* (photographed at Merriwindi) is a fossorial species often found in loose soil under large woody debris, and is part of the western (Eyrean) component of Merriwindi's herpetofauna community. Photo: M.J. Murphy.



The Nobbi *Diporiphora nobbi* (Australian Museum specimen R174487, photographed at Merriwindi) has been identified as a declining woodland reptile but is widespread in the Pilliga forest. Taking voucher specimens remains an important part of herpetofauna surveys. Photo: M.J. Murphy.



Nocturnal road transects were the most productive survey method for finding snakes in this study, including the brightly-coloured Australian Coral Snake *Brachyurops australis* (photographed at Merriwindi), another declining woodland reptile. Photo: M.J. Murphy.



The threatened Pale-headed Snake *Hoplocephalus bitorquatus* (photographed at Merriwindi) is a hollow-dependent nocturnal species with a wide but patchy distribution from the coast and ranges to the western slopes. Photo: M.J. Murphy.